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CONTENTS.

	Page.
Spraying at Sylee	143
Observations on the Treatment of Fungus Diseases...	151
Green Crops	170
Trials of Phosphatic Manures	176
Proposed Touring Programme for 1927	184
Index	185

SPRAYING AT SYLEE.

BY

C. R. HARLER.

It has been known for many years that leaf and stem diseases cause a loss in crop to the tea industry, but it is only recently that the seriousness of this loss has been realised. During the season 1925 observations were made in the Dooars primarily with the object of studying the development of tea mosquito blight (*Helopeltis thievora*) and its relationship to soil conditions. It was then noticed that much of the "shutting up" of bushes attributed to mosquito is actually due to leaf and stem diseases, the most important of which seems to be Brown blight. Corticium spp., Grey blight, Red rust and Nectria are also common on bushes seriously attacked by mosquito.

During the latter part of the 1925 season, stem diseases were so prevalent on parts of Sylee tea estate that the Manager decided to spray as much as possible of the area with lime-sulphur solution.

Sylee consists of two divisions, Sylee, 747 acres, and Nedeem, 453 acres. The total area is thus 1,200 acres. The garden is generally flat and supplied with good and convenient roads. A steady water supply is available.

The spraying material arrived in January, 1926, and operations were started at the end of that month. During the next four months the whole of the 1,200 acres was sprayed, making a daily average of about 10 acres. At the end of July spraying was again commenced but on a smaller scale and about 4 acres a day were covered.

If possible it is best to spray just after pruning, for at this time less solution is required because of the small amount of foliage. At the same time a stronger solution can be used on account of the absence of buds and young leaf which are burnt

by strong lime-sulphur. The solution is an alkaline one and, as such, it cleans the bark of the bush thereby inducing new growth. Lime-sulphur also kills Red spider.

Capital Cost of Spraying.

Making the solution.

Lime-sulphur solution is made up according to the formula given in the Scientific Department publications (*Quarterly Journal 111, 1925*). The method consists in slaking 20 lbs. quick-lime and then adding 30 gallons of water and bringing to the boil. When the solution is boiling, 22½ lbs. sulphur are added gradually with vigorous stirring. The solution is then made up to about 40 gallons and boiled for an hour with the addition of boiling water from time to time to keep the volume constant. Towards the end of the hour the volume is made up to 50 gallons. The solid matter is then allowed to settle and the solution diluted according to requirement. These directions must be followed closely, otherwise a solution of less density than 8 degrees Beaumé is obtained.

For making the solution, three 60-gallon cast iron pans of diameter and depth 2 ft. 6 ins. were used. These were heated over brick *chulas,* each built 4 ft. high, 7 ft. square and fitted with a brick chimney rising 6 ft. above the top of the *chula.* The pans were bricked in to within 8 inches of the rim. Usually two pans were sufficient to keep pace with the spraying and the third pan was used as a hot water container.

It is useful to arrange the grate under the pans so that it can slide out with the fire. Otherwise, when the solution is taken from the pan, the fire has to be raked out in order that the pan shall cool before more water is added.

The cost of the pans was Rs. 95 each and the approximate cost of building the *chulas,* including material, Rs. 300. A safe figure for the whole plant is Rs. 600 excluding the freight on the pans.

When the solution is made, it must be diluted according to the state of the bushes to be sprayed. Tables showing dilution are given in the *Quarterly Journal* referred to above. Over the whole area at Sylee an average of 140 gallons solution per acre was used at an average dilution of the stock solution of 6 parts water to 1 part solution. The term "average dilution" must be amplified for this does not mean that the dilution gradually changes according to the state of the bush. If there are no buds and young leaves on the bush the stock solution can be diluted with three parts water. When buds appear the dilution should be with seven parts of water. It is probable that the bushes can stand a stronger solution if the day be dull than if it be sunny. This is a contingency for which it is difficult to arrange so it is safer to keep a 7 to 1 solution as soon as buds appear.

With an average dilution of 6 to 1, 50 gallons of stock solution made 350 gallons of spray fluid which covered an average area of 2½ acres. This means that 20 lbs. quicklime and 22½ lbs. sulphur make enough solution to cover 2½ acres. The cost of sulphur is Rs. 140 per ton landed and of unslaked lime, in sealed tins, Rs. 77 per ton. The cost of lime and sulphur then works out at about 13 annas per acre.

A very rough estimate of the coal consumed in making the solution gives a figure of half a maund or a cost of 8 annas per acre.

The preparation of 50 gallons stock solution takes about 3 hours so on an average one pan can serve 5 acres a day.

The stock solution at Sylee was diluted into 250 gallon tanks placed on motor lorries which were used for taking the solution to the field. Two tanks each costing Rs. 100, exclusive of freight, were used.

The battery sprayer.

The pneumatic battery sprayer consists of a central charge pump, which pumps both air and liquid, and a number of knapsack sprayers

without any pump. At Sylee the "Four Oaks" Central Charge Pump, "No. 1, de luxe" pattern, was used.

The central charge pump is fixed across a tub containing the lime-sulphur solution and to begin with, air is pumped into the sprayer to 30 lbs. pressure. Then the air valve is closed and the liquid pumped in till the gauge registers 70 lbs. pressure. A cooly then takes the sprayer and sprays without any effort on his part except to carry the container and to direct the lance of the sprayer. When the solution is finished a ball valve automatically closes and the air at 30 lbs. pressure is retained. To recharge, it is only necessary to pump in more liquid.

One central charge pump can keep pace with about 8 sprayers. At Sylee, 3 pumps and 24 containers or sprayers were used. The cost of each pump was Rs. 454 and of each sprayer Rs. 128, making a total cost of Rs. 4,434 exclusive of carriage.

The repairs and losses are heavy even under European supervision. At the end of the day the compressed air should be released and the containers thoroughly washed out. On the efficiency of the washing depends largely the life of the sprayer. The sprayers themselves are liable to leak especially if they are dropped and dented. Pressure gauges on the central pump are a source of worry although very soon the cooly at the pump can tell by the pressure of the pump handle when the air pressure is correct. By feeling the container he can also tell exactly how much liquid is pumped in, for the metal gets hot in the sun and the rise of the cool solution can be accurately followed with the hand. The valves give very little trouble.

The capital outlay is as follows:—

Chulas and 3 pans ...	...	Rs. 600
2 tanks	...	,, 200
3 pumps and 24 containers	...	,, 4,434
		Rs. 5,234

Lime and Sulphur	...	As. 13 per acre.
Coal ...	...	,, 8 ,, ,,
		Rs. 1/5

The depreciation of the plant is very high. The cast-iron pans crack, of course, if water is poured into them when they are hot. This accident occurs sooner or later. The spraying plant, like all machinery used in agriculture, comes in for much hard usage. A safe depreciation figure is 50 per cent. per season. The depreciation cost for 1,200 acres then amounts to Rs. 2,612 or Rs. 2-3 per acre, making the expenditure on plant and materials Rs. 3-8 per acre per annum for a single round of spraying.

Labour.

Labour is required for making the solution, for the distribution of the spray fluid, for working the pump and for the actual spraying. In order that the sprayers shall start work as early as possible, solution should be prepared the day before and left overnight, protected by a thin film of oil. In the morning the lorry with the tank is driven to the *chulas* and whilst the solution is being transferred to the tank and diluted to the requisite strength, the containers are charged with air at 30 lbs. pressure. The pump, containers and coolies are then transported to the field.

It takes about 8 minutes for a container to discharge its solution when fixed with a single nozzle and 2 or 3 minutes to recharge it. Considerable organisation is required so that the 8 coolies who re-charge from the same central charge pump shall not all return to the pump at the same time. Only by constant arrangement can it be ensured that a container is actually spraying for the maximum time.

The number of bushes sprayed with one filling of the container varies widely with the size of the bushes and the amount

of foliage. With bushes planted 4½ ft. triangular, in foliage and fully grown, about 30 can be sprayed with one container. Taken over a period of 4 months it was found that one container can work about half an acre of tea a day.

Both single, double and four-nozzle attachments were used but the single nozzle was preferred. By this attachment the interior of the bush is reached and the spray directed with accuracy. An additional advantage of the single nozzle is the length of time it takes to discharge. It is extremely tiring to the cooly to have to return to the pump every two or three minutes for re-charging as is the case when the four-nozzle attachment is used.

It is difficult to give ultimate details as to labour costs, for they vary widely with the amount of solution used per acre. A useful figure may be obtained from the total labour charges on the spraying account over four months during which 1,200 acres were sprayed. This figure is Rs. 4-8 per acre, somewhat on the high side because, owing to the late start made with the spraying, the work had to be hurried with a resultant extra cost for labour.

During the latter part of the season when spraying was carried out under normal conditions the labour cost per acre was Rs. 4-12, but at this time 250 gallons of solution per acre were used against an average of 140 gallons in the cold weather. During this period an area of four acres a day was sprayed by 16 men, each receiving three haziras a day. The pumping was done by 6 men each receiving two haziras a day and the solution was made by 3 men each receiving two haziras a day.

It is possible that the cost of spraying may be still further reduced although an all-in reckoning of Rs. 8 per acre which includes Rs. 3-8 for plant and materials and Rs. 4-8 for labour, is a very safe estimate.

Spraying Experiments.

The Sylee Plots.

Since so much crop is lost because of fungus diseases on the leaves and stems of the tea bush, it was considered advisable to carry out experiments to determine to what extent the removal of these diseases either by pruning or spraying would influence the outturn. The experiments are outlined below.

Blocks of tea 60 bushes long by 12 bushes wide were chosen on five different parts of Sylee and Nedeem. Each block was divided into five plots, each in size 12 by 12 bushes. Each plot therefore contained 144 bushes.

The five plots were then treated as follows :—

Plot No. 1—Check
" " 2—Carefully pruned
" " 3 " " and sprayed
" " 4—Check
" " 5—Sprayed.

Thus, plots Nos. 1, 4 and 5 were pruned in the manner of the section in which the experimental block was taken, and No. 5 was sprayed. The ordinary pruning was generally the light prune as practised in the Dooars which consists in a cut across the bush. Nos. 2 and 3 in addition to the ordinary pruning were carefully gone over again and all weakly twigs and diseased stems removed. Plot No. 3 was also sprayed as well as carefully pruned.

The pruning was done at the end of January and plots Nos. 3 and 5 were then sprayed. These plots were thoroughly sprayed again in July.

So far as cultivation and manuring were concerned, all the plots received the same treatment as the sections in which they were situated. They were plucked in the ordinary round of the garden and the leaf from each block was accurately weighed at each plucking.

The complete experiment consisting of the five plots was thus repeated five times on different parts of the garden. The three sets of plots at Sylee were on the Mal sand and the two sets at Nedeem on the Red Bank.

Crop Figures.

The tables below show the monthly crop figures in pounds green leaf for each set of plots. Sylee No. IY is a section of young tea replanted in 1916 and top pruned for the season 1926.

SECTION—SYLEE NO. IY.

Month.	Plot No.				
	1 Check.	2 Pruned.	3 Pruned and sprayed.	4 Check.	5 Sprayed.
April	7	7	8	7	7
May	7	7	11	6	10
June	65	69	68	61	75
July	47	46	48	55	58
August	69	66	76	7	76
September	39	54	50	57	45
October	45	53	62	52	43
November	4	9	7	6	4
Total lbs. leaf ...	283	311	330	323	318

Without making any calculations it will be seen that no benefit is derived from spraying, No. 5 having yielded somewhat less than No. 4 block. The carefully pruned blocks Nos. 2 and 3 show a little advantage over the others. Section 1Y is young and healthy, with practically no twiggy growth and the benefit either from spraying or careful pruning is not marked as it is with older or with fungus-ridden tea.

The next table shows the yield from the plots on Sylee No. 9, a section of good tea, planted in 1883. The section was top-pruned.

SECTION—SYLEE No. 9.

Month.	Plot No.				
	1 Check.	2 Pruned.	3 Pruned & Sprayed.	4 Check.	5 Sprayed.
April	11	18	14	11	12
May	23	14	11	11	14
June	103	121	135	93	130
July	53	65	48	63	78
August	89	102	120	109	132
September	60	54	71	81	90
October	38	30	51	62	83
November	5	8	15	16	13
TOTAL lbs. LEAF ...	382	412	465	446	552

Here the great benefit derived from careful pruning and from spraying is well marked.

The next table refers to plots on Sylee No. 10, poor tea planted in 1883. This section was also top-pruned and like No. 9 has benefitted greatly by careful pruning and spraying.

SECTION—SYLEE No. 10.

Month.	Plot No.				
	1 Check.	2 Pruned.	3 Pruned & sprayed.	4 Check.	5 Sprayed.
April	18	17	15	13	12
May	28	19	16	21	19
June	62	94	74	49	66
July ...	83	85	67	53	65
August	52	57	62	42	50
September	52	54	50	41	50
October	43	56	49	38	34
November	24	26	19	15	11
TOTAL lbs. LEAF ...	362	408	352	272	307

Nedeem No. 2 is a block of very poor tea planted in 1883 and taken into the experiment because it is the worst block on the garden for mosquito blight.

SECTION—NEDEEM NO. 2.

Month.	Plot No.				
	1 Check.	2 Pruned.	3 Pruned & sprayed.	4 Check.	5 Sprayed.
April	9	9	14	15	17
May	16	22	28	24	28
June	57	91	75	58	81
July	56	51	56	50	57
August	77	75	93	59	82
September	50	54	50	38	58
October	31	25	21	17	23
November	7	6	7	5	7
TOTAL lbs. LEAF ...	303	333	344	266	353

The gain from spraying and careful pruning is well marked.

Nedeem No. 3 is also old tea planted in 1883, cut back at the end of 1924 and skiffed at the end of 1925 for the 1926 season.

SECTION—NEDEEM NO. 3

Month.	Plot No.				
	1 Check (skiffed).	2 Pruned.	3 Pruned & sprayed.	4 Check (skiffed).	5 Sprayed (skiffed).
April	13	18	18	18	15
May	57	31	30	41	49
June	80	67	74	81	80
July	69	61	54	64	68
August	103	101	102	96	94
September	93	71	87	89	81
October	52	54	52	54	56
November	23	24	27	29	29
TOTAL lbs. LEAF ...	490	427	444	472	472

Plots Nos. 2 and 3 show a serious deficit on the skiffed check blocks which is as might be expected. Spraying has had little effect.

Percentage Gains.

It is now necessary to calculate in some manner the percentage gains or losses following on careful pruning and spraying. This is a difficult problem for no initial fertility values are available so that any results calculated are only an approximation to the truth.

Some measure of the percentage gain of each plot may be obtained by comparing its yield with the average of the two check plots. Take for example the total yields given by the plots in block Sylee 1Y.

Block No. 1Y.	Plot No. 1 Check.	2 Pruned.	3 Pruned & sprayed.	4 Check.	5 Sprayed.
Total yield lbs. leaf ...	283	311	330	323	318

The average of the check plots Nos. 1 and 4 is 303 lbs. and and on this figure No. 2 plot shows an increase of 8 lbs. or 3 per cent.; No. 3 shows an increase of 27 lbs. or 8 per cent.; No. 5 shows an increase of 15 lbs. or 5 per cent.

Reckoning the gains or losses for all the plots on this basis we arrive at the following:—

Block.	% Increase of Plot No. 2 Pruned.	3 Pruned & sprayed.	5 Sprayed.
Sylee 1Y	3%	8%	5%
,, 9	*Nil*	12%	33%
,, 10	29%	11%	–3%
Nedeem 2	17%	19%	24%
,, 3	–11%	–8%	–2%

This method of calculation is however not very satisfactory for the fertility of the plots generally seems to fall off very definitely in one direction or the other and the arithmetic mean of the two checks may favour unduly or weigh against one or other of the blocks. Whilst realising that any values obtained must be only approximations to the truth, a more accurate method of measuring gains and losses than that given by the first method may be obtained as follows. Suppose that the block improves more or less regularly in one direction then the increase or decrease from one check or the other may be spread

equally over the intervening blocks. Thus on Sylee No. 10, check plot No. 1 yielded 362 lbs., and check plot No. 4 yielded 272 lbs., a difference of 90 lbs. The actual yields of all five plots are shown below.

Block Sylee No. 10	Plot No.				
	1 Check.	2 Pruned.	3 Pruned & sprayed.	4 Check.	5 Sprayed.
Total lbs. leaf ...	362	408	352	272	307

Had there been no special treatment and assuming that the fertility decreased regularly, then the crops would have been as follows :—

Total lbs. leaf 362 332 302 272 242.

The checks Nos. 1 and 4 being the same and Nos. 2 and 3 decreasing each by 30 lbs. and No. 5 showing a further 30 lbs. in default of No. 4. The percentage gains or losses would then be calculated on these figures. Thus No. 2 shows a gain of 76 lbs. on 332 lbs., *i.e.*, 23 per cent. to the good. Similarly No. 3 shows a gain of 17 per cent. and No. 4 a gain of 27 per cent.

Treating all the blocks similarly we get the following gains and losses :—

Block	% Increase of Plot No.		
	2 Pruned.	3 Pruned & sprayed.	5 Sprayed.
Sylee 1Y	5%	7%	–5%
,, 9	2%	10%	18%
,, 10	23%	17%	27%
Nedeem 2	14%	22%	39%
,, 3	–11%	–7%	2%

When this table is compared with the previous one showing percentage increases calculated on the mean of the two check plots, it will be seen that but for the plots on Sylee No. 10 the gains and losses are comparable in both tables.

Sylee No. 1Y shows a small gain not definite enough to be considered significant. The reason for this is, as stated above, that the tea is young and healthy with clean wood. It evidently does not pay to spray nor severely clean out such tea.

Sylee No. 9 is old, healthy tea which does not respond to cleaning out but does to spraying. The tea on this block improves from plot No. 1 to plot No. 5 and the gain shown in the second table is probably nearer to the truth than that shown in the first table.

Sylee No. 10 is a block of tea situated between cooly lines at one end and a bazar at the other. The tea at both ends of the block is better than that in the middle. Plot No. 3 had the poorest initial fertility and the tea improved both towards plots Nos. 1 and 5. The calculation made in the first of the two tables undoubtedly shows too small an increase in plot No. 3 whilst the calculation in the second table shows too great an increase. Sylee No. 10, the block under consideration, would probably respond more to careful pruning than to spraying, although both are needed.

Nedeem No. 2 responds to spraying rather than pruning.

Nedeem No. 3 was skiffed and as might be expected shows a loss from careful pruning. The gain from spraying in this series is nil for the wood is new and clean, following on a medium prune of two years ago.

From the above it will be observed that the wholesale spraying of a garden is not to be recommended but only when the wood is badly affected by fungi. In other cases, with areas similar to Sylee No. 10, careful pruning pays better than spraying.

On Sylee garden, areas like Sylees No. 1Y and Nedeem No. 2 represent only a small part of the whole area. By far the greater part of the garden is represented by tea similar to that on Sylee Nos. 9 and 10 and Nedeem No. 2. It is thus possible to calculate roughly what gain in tea per acre certain

blocks made from spraying and also what might have been gained or lost from severe cleaning out.

The tables below show these gains or losses. Each block measures 3/35th acres and by taking the tea to leaf ratio as 1 to 5, the gain in tea per acre may be calculated. The ratio 1 to 5 is taken because during the season 1926 the Sylee leaf contained nearer 80 than 75 per cent. moisture.

The calculations are made both on the mean of the checks and on the assumption of a steady fertility change from plot No. 1 to plot No. 5.

Taking first the gains calculated on the mean of the checks we get the following :—

Plot No.	Treatment.	Gain lbs. tea per acre.		
		Sylee No. 9.	Sylee No. 10.	Nedeem No. 2.
2	Pruned	*Nil*	212 lbs.	112 lbs.
3	Pruned and sprayed ...	119 lbs.	78 lbs.	138 lbs.
5	Sprayed	322 lbs.	*Nil*	159 lbs.

Calculating by the second method the following table is obtained :—

Plot No.	Treatment.	Gain lbs. tea per acre.		
		Sylee No. 9.	Sylee No. 10.	Nedeem No 2.
2	Pruned	21 lbs.	177 lbs.	98 lbs.
3	Pruned and sprayed ...	96 lbs.	117 lbs.	152 lbs.
5	Sprayed	198 lbs.	152 lbs.	231 lbs.

Whilst no very definite estimate of the gain made by spraying Sylee garden can be made it seems clear that the areas in need of spraying, like Sylee No. 9 and Nedeem No. 2, must have given very large increases per acre.

The plots will be treated again in 1927 and the crop records kept.

OBSERVATIONS ON THE TREATMENT OF FUNGUS DISEASES.

By

A. C. Tunstall.

For many years the scientific departments associated with the tea industry have been patiently investigating the various diseases of the tea plant caused by vegetable parasites. The life histories of all the commoner disease producing fungi have been worked out and we are now in a position to devise specific treatments for most of them.

In the course of our investigations it has frequently been observed that the vigour of the tea bushes themselves had a profound influence on their susceptibility to many diseases. For instance Brown blight, Red rust and *Thyridaria* are only found on bushes which have been weakened by other conditions. Improvement in the general health of the bushes by better manuring, draining, etc., has been found to reduce the ravages of these and similar diseases to a very great extent This fact was recognised very early in our investigations and planters were advised accordingly.

It was further recognised that another group of diseases *e.g., Poria Sp.,* Jew's ear fungus and other common wood destroying fungi only attacked bushes which had been pruned in an unsatisfactory manner. Improvement in the pruning has reduced these diseases in the districts where the pruning has been carefully attended to for a period of years.

It may be pointed out that in many cases the acceptance of the observation of the fact that improvement in the general health of the bushes will enable them to overcome certain diseases has directly resulted in the application of more scientific methods to tea culture. It is no exaggeration to say that in some of the tea districts a serious outbreak of fungus disease

has led to the recognition of the usefulness of the scientific methods to which their present prosperity is due.

There remain a number of diseases which we have been unable to influence to a sufficient extent by attention to general cultural operations such as draining, manuring, pruning, etc. For these, direct fungicidal methods are necessary. In some cases *e.g.*, root diseases, the removal of the infected plants is the only satisfactory method. Where this has been carried out carefully these diseases have ceased to be a menace. In other cases such drastic methods as the removal of the plants are unnecessary and the application of fungicidal solutions has been found to be satisfactory *e.g.*, in the case of Thread blight, Black rot, *Corticium sp.*, etc.

Attention has been paid to the selection of a satisfactory fungicidal fluid. The old established Bordeaux mixture was first employed. This proved to be quite satisfactory when it was properly prepared, but considerable difficulty was experienced in its preparation under tea garden conditions. Burgundy mixture was then tried. This was much easier to prepare. There was still a drawback however. Like Bordeaux mixture, Burgundy mixture is a precipitate and in consequence requires constant stirring during its application. Lime sulphur solution was then experimented with. This fungicide is easy to prepare and easy to apply. It possesses the additional advantage of being an insecticide as well. Although it does not kill many animal parasites it is particularly effective against some of the commonest ones *e.g.*, Red spider. As a fungicide it is not so efficient as Burgundy or Bordeaux mixtures but it has proved itself more generally useful.

While attention was being paid to spray fluids much was being done in the investigation of practical methods of applying them. Comparatively few years ago the idea of applying spray fluids to large areas was ridiculed by most planters and over and over again the scientific department was accused of advocating hopelessly impractical methods. Many of those

methods have long since been accepted as part of the general routine. Companies which were horrified at the idea of spending Rs. 5 per acre on pruning now spend more than double that amount with beneficial results. Scientific manuring has also been accepted by all up-to-date concerns. Spraying is however only just receiving the recognition it deserves. It has now been proved beyond question that the application of spray fluids to large areas is a practical proposition and the results are such that its utility cannot be denied.

With better manuring, pruning, etc., the vigour of the tea bushes has been so improved that many diseases which formerly caused severe damage are now negligible. With the acceptance of spraying as part of the general routine most of the remainder will also disappear.

General Treatment.

The general improvement in health brought about by more scientific manuring, pruning, etc., will not affect some diseases *e.g.*, Black rot, *Corticium*, etc. At the same time if these diseases are not reduced the general improvement in the health of the bushes is seriously delayed. It is therefore desirable to include direct fungicidal treatment in the general routine of tea cultivation in all districts.

It is suggested that the whole area be sprayed with Lime sulphur solution once immediately after pruning and a second time soon after the new leaf appears. If it is found impossible to spray the whole area more than once, sections should not be sprayed until the new leaf appears. The remainder should be sprayed immediately after pruning.

For general spraying Lime sulphur solution is recommended. Burgundy mixture is only recommended for use in special cases such as the treatment of odd bushes here and there. It is more suitable than Lime sulphur for this purpose as it leaves definite indications of its application. It is thus possible to judge the efficiency of the work more readily.

For General Application.

Lime sulphur solution is the most satisfactory. This solution is best prepared according to the following formula :—

Quicklime	...	...	20	lbs.
Sulphur	...	...	22½	lbs.
Water	...	...	50	gallons

The lime should be put into a drum of 50 gallons capacity and slaked by adding water gradually. When it is fully slaked, add about 30 gallons of water and bring to the boil. When it is boiling add the sulphur gradually, stirring vigorously during the whole time, and when all the sulphur has been added pour in boiling water to the 50 gallons mark. Boil for an hour longer, keeping the volume at 50 gallons by adding boiling water. This gives the stock solution which, when cool, may be diluted with the volumes of water indicated in the table and used immediately. This solution has a specific gravity of about 8 degrees Beaumé.

Great care must be used in its preparation, and if it be desired to keep the stock solution, it must be stored in full, air-tight vessels, or, if the vessel is not full, with a layer of oil on the surface.

Lime sulphur solution should not be stored in copper vessels or sprayed on to the bushes from copper spraying machines. Great care must be taken to see that all spraying machines are thoroughly cleaned out after use.

The sediment need not be thrown away but may be boiled up with about 10 gallons of fresh water. The resulting liquid should be tested, when cold, with a hydrometer and diluted according to the table given below. The water used for diluting the stock solution may be mixed with fresh cattle manure and carefully strained. This makes the fluid stick on better and renders it visible on the leaves.

The solution is very useful for the treatment of itch and ringworm on coolies.

In some cases it may be found desirable to obtain ready made Lime sulphur solution. This is much more concentrated and should always be bought under a guarantee of a definite specific gravity. If the solution varies in strength it will be found very difficult to use economically. In any case the concentrated solution should be tested by means of a hydrometer and diluted according to the table given below.

Beaumé hydrometers for liquids heavier than water may be obtained in Calcutta for about Rs. 7 each.

READING OF HYDROMETER IN COLD SOLUTION.		AMOUNT OF WATER TO BE ADDED TO ONE PART OF THE CONCENTRATED SOLUTION.				
		COLD SEASON.		GROWING SEASON.		
In degrees Beaumé.	In specific gravity.	Heavy Pruned tea without buds.	Heavy Pruned tea with buds and all other tea.	Ordinary tea.	Heavy Pruned and young tea.	Nurseries.
8	1·057	2	3	6	7	8
9	1·064	2½	3½	6½	7½	8½
10	1·072	2½	3½	6¾	7¾	9
11	1·080	2¾	3¾	7½	8½	9¾
12	1·088	3	4	8	9¼	10¾
13	1·096	3¼	4½	8¾	10¼	11¾
14	1·104	3½	5	10	11½	12¾
15	1·113	3¾	5½	10½	12¼	14
16	1·121	4	5¾	11¼	13¼	15
17	1·130	4¼	6	12	14	16
18	1·138	4½	6½	12¾	14¾	17
19	1·147	4¾	7	13¾	16	18¼
20	1·157	5	7½	14¾	17¼	19¾
21	1·166	5¼	8	16	18½	21¼
22	1·176	5½	8½	17	20	22¾
23	1·185	6	9¼	18¼	21¼	24¼
24	1·195	6½	9¾	19½	22¾	26
25	1·205	7	10¼	20¾	24¼	27¾
26	1·215	7¼	11¼	22¼	25¾	29½
27	1·225	7¾	11¾	23¼	27¼	31
28	1·235	8¼	12¼	24½	28¾	32¾
29	1·245	8½	12¾	25¾	30	34¼
30	1·256	9	13½	27¼	31¾	36¼
31	1·267	9¼	14	28	32¾	37½
32	1·278	10	15	30	35	40
33	1·289	10¼	15½	31	36	41¼
34	1·300	10¾	16¼	32¾	38	43¼
35	1·312	11¼	16¾	33¾	39¼	45

Note.—The formula for Lime sulphur solution given above will give a concentrated solution of about 8 degrees Beaumé.

For use on Isolated Bushes.

Burgundy mixture is recommended because it can be seen readily on the leaves and stems. It is therefore easy to check the work. This is specially important in the case of isolated bushes.

To make 50 gallons 1 per cent. Burgundy mixture dissolve 5 lbs. of crystallised copper sulphate by suspending it in a piece of sacking, in two and half gallons of warm water (if required immediately). If cold water is used the copper sulphate may be left to dissolve overnight.

In the same way dissolve 2.3 lbs. of soda ash.

Add the soda ash solution gradually to the copper sulphate solution, stirring all the time, until the mixture becomes neutral. This can be tested with litmus paper. The solution should be either neutral, or very slightly alkaline but never acid. The mixture will not be affected to any great extent by standing for a short time in iron vessels, but the copper sulphate solution will be. It is therefore necessary to dissolve this substance in wooden, copper or earthen vessels. The soda ash attacks iron a little but not sufficiently to make any serious change in the solution.

The addition of the above mixtures will make 5 gallons concentrated mixture which when diluted to 50 gallons will be 1 per cent. Burgundy mixture.

Litmus paper is made up into little books of thin strips. It is either blue or red. The red colour may be changed to blue by alkalis and *vice versa* by acids. Neutral solutions do not affect the colour of either paper.

Adhesive for use with Burgundy Mixture.

Washing soda	... 1 lb.
Resin (common resin or colophony)	... 2 lbs.
Water	... 1 gallon.

Boil the water, then add the soda. When dissolved, add the resin and boil for about an hour, stirring continually.

Add this when cool, to Burgundy mixture at the rate of one gallon to the every 24 gallons of Burgundy. The addition of this solution makes the mixture stick to the leaves better.

It also overcomes the tendency to form drops and the mixture spreads out as a thin film.

The Treatment of Pruning Cuts.

So far no really satisfactory paint for pruning cuts has been found. All have their drawbacks. The most satisfactory method of treatment is by spraying with Lime sulphur solution immediately after pruning. The larger cuts may then be coated with a paste made of fresh cowdung and mud. This paste is used with the object of keeping the wound moist and thus facilitating the formation of callus.

A suitable brush for painting cuts is made as follows :—

Take a piece of bamboo about 1½ inches in diameter and 2 ft. long, having a knot at each end. Bore out the knots with an auger. Take a piece of tow of sufficient size, tie a piece of wire round the middle leaving an end long enough to go the length of the bamboo and project at the one end. Thread the wire through the bamboo and pull the tow into position at the end. Fix the loose end by means of a wooden plug driven into the hole.

Spraying Figures.

In the " Battery " system one charge pump is required to every 8 containers. One container working under ordinary garden conditions can spray half an acre per day.

Each battery consisting of 8 containers, and a pump requires 10 men to do the actual spraying.

In addition other coolies are required for the treatment of the solution and water. Their number varies considerably

according to conditions. Coolies are also required for the preparation of the concentrated solution.

The average amount of diluted solution required per acre is 150 gallons on pruned tea and 250 gallons on unpruned tea. The strength of this solution will vary (see table).

SPRAYING MACHINES.

Requirements for 1,000 acre Garden.

As general spraying can only be done satisfactorily during the cold weather we may assume that about 100 days are available. If the spraying is done twice it would be necessary to spray 20 acres per day. To spray 20 acres in one day 40 containers are required. As each 8 containers require one charge pump 5 of the latter will be required.

If an average of 150 gallons of diluted fluid is required for 1 acre of pruned tea arrangements must be made for the transport of 3,000 gallons of fluid per day. Of this fluid as much as 1,000 gallons may be concentrated solution. So arrangements must be made for the manufacture of 1,000 gallons of concentrate per day. If steam is available it would be economical to use a 1,000-gallon tank and prepare the whole quantity for each day at one time. In other cases it would be necessary to construct *chulas*.

A satisfactory arrangement may be made by building in 60-gallon iron pans. To prepare 50 gallons of solution takes about 3 hours. If two lots of solution are made per day of 6 hours 10 pans would be required.

Tanks would also be required for the transport of water and concentrate. The number of these depends on the accessibility of the area to be sprayed. On an average four 250-gallon tanks would be required if lorries are available for their transport. A proportionately larger number of smaller tanks would be necessary if other means of transport are employed.

To summarise the apparatus necessary to spray 1,000 acres twice in 100 days would be :—

1.	40 containers with spares, etc., at Rs. 125 each	Rs. 5,000
2.	5 charge pumps with spares, etc., at Rs. 450 each	,, 2,250
3.	4, 250-gallon tanks at Rs. 100 each	,, 400
4.	10, 60-gallon pans at Rs. 100 each and necessary building ...	,, 1,200
		Rs. 8,850

The depreciation on the above would be about 50 per cent. on item 1 and say 20 per cent. on the remaining items, *i.e.*, a total of Rs. 3,270 per annum, say Rs. 3-8 per acre.

The sulphur and lime required per acre works out in practice at about 13 annas for one application and the fuel required for boiling the solution at about 8 annas per acre for each application making a total Rs. 1/5 per application. Rs. 3 for both applications.

Each battery consisting of eight containers and one charge pump requires 10 men to do the actual spraying, *i.e.*, 50 men per day. An equal number would be required for preparation of solution, transport, etc., *i.e.*, 5 men to spray one acre once, *i.e.*, 10 men to spray one acre twice. If they are paid 8 annas per day it would come to Rs. 5 per acre for two applications.

The cost per acre per annum of two applications would therefore be approximately as follows :—

	Rs.	As.	P.
Machinery	3	8	0
Chemicals and fuel	3	0	0
Labour	5	0	0
Total Rs.	11	8	0

First Aid for Tea Diseases.

It is fairly obvious that the treatment of fungus disease is by no means simple.

The planter is not in a position to diagnose and prescribe treatment. If specimens are sent to Tocklai it takes at least a week to get a reply for postal reasons alone. In disease treatment, time is a most important factor and knowledge of first aid is of the utmost importance. The following suggestions are first aid only to the diseased bushes. They should always be supplemented as soon as possible by expert knowledge. Specimens of the diseased plants should be sent to Tocklai at once with full particulars.

What to do when an Outbreak of Serious Disease is Discovered.

Always send specimens of any unrecognised disease to Tocklai at once, with full particulars of soil, jat and age of tea, weather conditions during the development of the disease, extent of damage, and any other relevant details. The disease may be doing little damage but under other conditions it may become serious. If the specimen is sent to Tocklai the Department is able to investigate the disease and is in a better position to suggest remedies should the disease at any time become serious.

In the Case of Stem or Leaf Diseases.

1. Isolate the bushes concerned by preventing coolies, cattle, etc., from touching them. All the necessary cultivation, etc., should be carried out by special coolies, using specially marked implements. At the conclusion of the operations for the day the coolies and implements should be sprayed with Lime sulphur solution on the spot so that the disease will not be carried about.

The Lime sulphur solution does not injure the skin or clothing but should not be allowed to get into the eyes.

2. Pluck or prune off all the diseased portions and burn them on the spot. If they are too green to burn alone a little kerosene will help matters.

3. Spray the bushes thoroughly with a fungicide, *e.g.*, Lime sulphur.

4. Repeat the plucking, pruning and spraying at intervals depending on the nature of the disease (*vide* advice received from Tocklai).

Where there are numerous outbreaks occurring at the same time, treat the small ones first, isolating the larger areas until time permits treatment to be carried out on them.

In the Case of Root Diseases.

1. The areas containing the dead and dying bushes should be isolated and all the implements used in cultivation, etc., of such areas should be kept separate. There is no need to disinfect the coolies.

2. The edges of the large areas and all small areas should be dealt with first by digging out the dead and diseased bushes, taking great care to remove all the dead wood from the soil.

3. All the dead wood should be burned on the spot if possible. If it is not feasible it should be removed in old bags or baskets and burned elsewhere. Care should be taken to either burn the bags or baskets or disinfect them thoroughly with Lime sulphur solution.

4. Watch for new outbreaks and deal with them at once.

5. Dig out all dead wood and lime the soil some months before replanting.

In planting out be very careful to clear out all the dead stumps. This operation is costly but very desirable. Jacks are very useful for removing smaller trees and the large stumps may be used as centres for burning of piles of wood collected round them.

The following table gives a rough indication of the treatment required to deal with the commoner vegetable parasites of the tea plants in North-East India.

Green Portions		Woody Portions		
Leaves	Shoots	Stems	Roots	
Blister blight (*Exobasidium vexans*, Mass).	Blister blight	.....	.....	Curable by spraying.
Copper blight (*Laestadia Theae*, Rac).	.....	.....	.....	
Thread blight	Thread blight	Thread blight	.....	
Black rot (*Corticium invisum*, Petch).	Black rot			
	Corticium Sp.	*Corticium Sp.*		
Brown blight (*Colletotrichum Camelliae*,	Brown blight	Mass).		
Grey blight (*Pestalozzia Theae*,	Grey blight	Grey blight Sawada).		
Red rust (*Cephaleuros myc*	Red rust	*oidea*, Kart).		
	Nectria (*Nectria*	*Nectria cinnabarina*, Tode, Fr.)		Alleviated by spraying.
		Die-back (*Thyridaria*	Die-back *tarda*, Bancr).	
		Black root rot (*Rosellinia a*	Black root rot. *rcuata*, Petch).	
		Dead snag fungi— *Poria, Auricularia, etc.*		
Brown blight (*Colleto*	Brown blight *trichum Camelliae*,	Mass).		
Grey blight (*Pest*	*alozzia Theae*, Sa	wada).		
Red rust (*Ceph*	*aleuros mycoide*	*a*, Kart).		Alleviated by improving soil and bush conditions.
		Die-back (*Thyridaria*	Die-back *tarda*, Bancr).	
		Black root rot (*Rosellinia a*	Black root rot *rcuata*, Petch).	
		Violet root rot (*Sphaertilbe*	Violet root rot *repens*, B & Br).	

Green Portions		Woody Portions		
Leaves	Shoots	Stems	Roots	
	Red rust (*Oephaleuros*	Red rust *mycoidea*, Kart).		Alleviated by improving pruning.
	Nectria *Nectria cinn*	*Nectria* *abarina*, Tode, Fr).		
		Dead snag fungi —*Poria*, *Auricularia*,	etc.	
	Nectria (*Nectria cinn*	*Nectria* *abarina*, Tode, Fr).		Must be cut right out.
		Dead snag fungi *Poria*, *Auricularia*,	etc.	
			Charcoal stump rot	
		Charcoal stump rot (*Ustulina Zo*	*nata*, Sacc).	
		Black root rot (*Rosellinia a*	Black root rot *rcuata*, Petch).	Must be dug right out.
			Brown root rot (*Fomes lamaoensis*, Marr).	
			Other root diseases	

Our special knowledge of the life histories of certain of the pests and blights of tea would seem to indicate that the above treatment will fail to prevent them. It is possible, however, that the removal of the remainder will render the tea bush more or less immune to them also. We may however be left with a few diseases. Our special knowledge will then be applied to the eradication of these.

For the past fifteen years the tea industry has been expending considerable sums of money and a great deal of patience while the foundations of our present knowledge were being laid. Although the application of the results already obtained has repaid the expenditure over and over again, it seems probable that the results in the near future, when the application of spray fluids becomes a part of the general routine of tea culture, will convince even the most sceptical.

GREEN CROPS.

BY

P. H. CARPENTER.

In order that a soil shall maintain its fertility a constant supply of organic matter is necessary. One of the reasons why a jungle soil maintains its high state of fertility is that it annually receives considerable additions of organic matter in the form of falling leaves and withering undergrowth.

The need for organic matter.

On land that has been growing tea for many years and which has been consistently cultivated, the rate of loss of organic matter exceeds the supply given by the yearly fall of leaf and the light prunings returned to the soil. On this account the organic matter or humus steadily decreases till it reaches a very low level. The result is a soil giving a small crop. It must be remembered that a jungle soil receives no cultivation, and accordingly the decomposition of the humus proceeds at a slow rate, and is consequently conserved to such an extent that the soil gathers humus as time passes.

It thus follows that as a rule the tea soils of North-East India are deficient in organic matter, and whilst the necessity for replenishing this soil essential is realised, it not infrequently happens that green cropping as a method for supplying organic matter is out of the question because some soils fail to grow such crops. This may be due to the shortage of some soil mineral like lime or phosphoric acid; to the shortage of organic matter and nitrogen; or even to the prevalence of some fungus disease. This latter contingency arose at Borbhetta a few years ago when the presence of *rhizoctonia* in the soil, a root disease attacking some plants but not pathogenic to tea, completely arrested the growth of Boga medeloa.

The increased development of thatch grass on old tea land can be taken as evidence of the necessity for adding organic

matter. Not that thatch grass prefers poor soil to rich but that on a poor soil the competition from other weeds is reduced.

In some cases soils rich in organic matter also fail to grow tea and many instances of deteriorated bheels may be quoted where the organic matter of the soil is as much as 20 to 30 per cent. but the tea does not thrive. In these cases the addition of organic matter either as green crop or as cattle manure failed to revive the tea for the fault lay in the physical state of the organic matter in the soil. Bheels which have thus deteriorated have done so because alternate drying and wetting has robbed the humus of its colloidal, "sticking" properties.

Under the climatic conditions experienced in North-East India which include the two factors, heavy rainfall and high temperatures, the steady loss of humus calls for the systematic addition of organic matter to the soil. This can be accomplished in several ways.

Organic matter is best added as cattle manure or good top dressing material, but few gardens are in the happy position of possessing either of these materials in sufficient quantity or in an economically available position. Every endeavour should be made to collect and utilise the cattle and line manure available. This often requires careful organization but such effort is amply repaid in the results obtained. The use of bheel soil as a top dressing should also receive careful consideration but it is necessary here to issue a word of warning that the appearance of such material is often misleading. It is always advisable to have accurate data, obtained from analysis, of the percentage of organic matter and also of the nature of the remainder of the dressing, whether it is a heavy clay or of a sandy nature.

Green cropping.

The majority of gardens have to seek some other source of organic matter and this is most conveniently found in green cropping. The supply of any form of green plant material benefits the soil but it has been found most economic to utilise plants able to make use of atmospheric nitrogen in their growth. Such plants belong

to the order Leguminosæ. Plants other than Leguminosæ supply organic matter equally well but are unable to utilise nitrogen directly from the air.

Ordinary plants obtain the nitrogen used in growth from the soil and when they are cut and buried, merely return to the soil the nitrogen which they have previously taken from it. It pays to carry jungle from hullahs and outside areas and to bury it on the garden, but it has been shown that such jungle gains in efficiency if it is rotted off the garden before it is buried.

There are many substances used as nitrogenous manures which also supply organic matter to the soil. Oilcake, fish manure, animal meal and blood meal are manures of this type but they are expensive, costing from Rs. 3 to Rs. 6 per maund. It is possible to add large quantities of green manure, —4 or 5 tons—for a cost of about Rs. 10. The green crop contains about 80 per cent. moisture so that a five-ton crop represents about one ton of dry organic matter. This corresponds with about two tons cattle manure (containing about 50 per cent. moisture) or about 32 maunds oilcake (containing 10-15 per cent. moisture) so far as organic matter is concerned although no account of the nitrogen content is taken here.

Systematic manuring.

It was thought at one time that it might be possible to add all the nitrogen required by the tea plant entirely in the form of green organic matter. Experiments carried out at Tocklai have shown that over a period of five years the annual application of 30 lbs. nitrogen in the form of green organic matter brought in from outside and buried in the plot has not resulted in nearly as good a crop increase as that shown by the annual application of the same quantity of nitrogen given in a soluble form. The condition of the soil has however been greatly improved by this constant green manuring and the bushes have a healthier appearance than those receiving only soluble manures.

Whilst then green crops can be used to supply some of the nitrogen needed by the tea plant it is preferable to use it to supply organic matter and to add nitrogen in the artificial form as calcium cyanamide, sulphate of ammonia or nitrate of soda. Taking this principle as a basis it is possible to construct a manuring scheme suitable for gardens where a supply of organic matter in excess of that given by falling foliage and light prunings, is necessary. As examples the following two cycles are suggested.

Three Year Cycle.

First Year. Quick growing green crop such as cow-peas and phosphoric acid added as 2 mds. basic slag, superphosphate or bone meal, or 2 cwt. Belgian Flour Phosphate.

Second Year. 30 lbs. readily available nitrogen 20-30 lbs. Potash per acre, broadcast with early rain.

Third Year. Rahar in alternate lines, lopped at intervals and buried at end of season.

Fork in a quick acting mixture round the bushes which shall give—30 lbs. readily available nitrogen, 20-30 lbs. Potash, 20-30 lbs. phosphoric acid, per acre.

The heavier dose of Potash and lighter dose of Phosphoric acid should be applied to a sandy soil and the opposite to a clay soil.

Five Year Cycle.

First Year. As above in three-year cycle.

Second Year. As above in three-year cycle.

Third Year. Boga medeloa in alternate rows; complete mixture as above forked round bushes.

Fourth Year. Complete mixture as above forked round bushes.

Fifth Year. Bury Boga medeloa at beginning of the year.

Common Green Crops.

It is sometimes difficult to know which green crop should be grown, and in deciding this, local knowledge is most valuable. It is important to obtain the greatest weight of green matter as opposed to woody material, and the crop chosen should be that which is known to grow most luxuriantly upon the particular type of soil. Apart from this there is no particular virtue in one crop over another apart from convenience.

The same crop should not be grown year after year on the same area otherwise the soil may become "sick." If a scheme based on that suggested above is followed then this factor is eliminated.

The table below supplies a few details of the more commonly grown green crops.

Name of plant.	Rate of seed per acre.	Planting.	Crop.	Growing period.
Cow-peas (*Vigna catiang*) ...	40 lbs.	every row	3 tons	6-10 weeks
Mati kalai (*Phaseolus mungo*) ...	30 lbs.	,,	,,	,,
Bhotmas Soy bean (*Glycine hispida*)	40 lbs.	,,	,,	,,
Sunn Hemp (*Crotolaria jauncia*) ...	40 lbs.	,,	,,	,,
Dhaincha (*Sesbania arcuata*) ...	40 lbs.	,,	,,	,,
Arhar or Rahar (*Cajanus indicus*)	10 lbs.	alternate rows	5 tons.	8-10 months
Boga medeloa (*Tephrosia candida*) ...	10 lbs.	,,	,,	2 years
Indigofera dosua	10 lbs.	,,	,,	4-5 years

Cow-peas, Mati kalai and Soy beans are twining plants whilst Sunn Hemp and Dhaincha grow straight up. Arhar, Boga medeloa and Indigofera need to be well-lopped into an umbrella shape or otherwise a serious loss in tea crop will be experienced. At the end of one year Boga medeloa should be thinned out to clumps about 12 feet apart. Indigofera is more suited to the hills than the plains.

Both Boga medeloa and Indigofera may be used for filling in trenches but if the woody material is buried there is a danger that root rot may spread along the trench. It is safe when trenches are made to leave a few inches uncut every few yards and this block of soil will act as a stop to diseases which are carried by dead wood in the trenches.

It is not advisable to grow Boga medeloa for more than two years, although if soil is in good condition it may be left up for three years. Indigofera may be grown for several years but it is susceptible to the root disease, Ustulina Zonata, as it ages. The roots of old Indigofera are difficult to remove from the soil but if left in they may act as a source of infection to the tea.

Both perennial and annual green crops are of particular value in ridding an area of thatch grass although it is recognised that a better method of achieving this end is by a heavy application—15 tons—of cattle manure or by a top dressing of about 20 tons per acre.

Many green crops are failures because the rate of sowing is too small so that when the race between jungle and crop starts with the early rains the jungle is able to choke out the green crop. The seed quantities recommended above are liberal and if a seed bed is well prepared and the seed sown carefully so as to ensure a high percentage of germination then smaller quantities could be used. In some gardens it is found possible to weed the green crop in its early stages and this has been found to pay, especially with crops like Rahar and Boga medeloa, which are left growing for one or two seasons.

With care, good green crops can be grown in fully grown tea which has been ordinarily top pruned. In some cases the soil is so poor in nitrogen that a green crop cannot get a start. In this case a small application of nitrogenous manure, for example, one maund nitrate of soda per acre, is advisable. This, with two maunds of basic slag per acre, will ensure a successful green crop on practically any tea soil in North-East India.

TRIALS OF PHOSPHATIC MANURES.

BY

H. R. Cooper and P. B. Sen Gupta.

Manures which supply phosphoric acid only very rarely give any significant increase of tea crop, when used alone. When nitrogenous manures are regularly applied however, it is nearly always necessary to supply also some phosphoric acid. Unlike nitrogen, phosphoric acid is not removed to any appreciable extent by washing out of the soil. For the sake of the tea crop, it is therefore not necessary to apply phosphoric acid in annual small doses, but comparatively large dressings at intervals of a few years may be given.

This fact is made use of in the practice of applying a large part of the phosphoric acid required during a rotation of manuring, in the year when a green crop is sown. Unlike tea, leguminous crops, on most soils, do benefit from phosphoric acid alone. The use of a manure supplying phosphoric acid induces better root growth, and an increased development of root-nodules, with consequent immediate benefit to the plant. It also hastens maturity, so that a larger plant with a higher nitrogen content is produced within the short time during which it is desirable that a green crop should occupy the soil.

It is recommended, generally, therefore, that a good dressing of phosphate should be given before a green crop is sown, and that in order to get an effectively increased green crop, the dressing should be such as will make unnecessary the addition of further phosphate for one or two years.

If phosphates are to be used in this manner it is essential that they shall be rapid enough in action to give a really significant increase in weight of green crop within the short period of about six weeks during which the green crop can be allowed to grow.

In the trials described below the manures were applied, and hoed in lightly just before sowing *mati kalai* which was pulled up and weighed six weeks later. These trials therefore

measure the efficiency of the manures under the conditions in which they will be most used in tea cultivation. From the more general standpoint they measure the immediate efficiency of the manures within a period of 6 weeks after application.

Previous trials on our acid soils had shown that basic slag has the greatest immediate efficiency of all phosphatic manures. Basic slag was therefore used as the standard for comparison.

Seed was sown in single lines, each line treated with manure under trial having an unmanured line on one side, and a line manured with basic slag on the other side.

For each manure under trial there were six such sets of three lines.

Manures were spread evenly over a strip of soil 14½ feet long by 1½ feet broad. The area of each strip is thus $\frac{1}{200}$ of an acre. The manures were weighed out on an accurate chemical balance. Exactly ¼ oz. of *mati kalai* seed was sown in one line down the middle of each strip. All manures were applied, after analysis, to give exactly 80 lbs. phosphoric acid per acre.

The cost of applying this dressing varied considerably as will be seen from the following table.

TABLE I.

Cost of application of phosphatic manures to supply 80 lbs. phosphoric acid per acre.

	Manure.	Phosphoric acid content.	Quantity of manure required per acre.	Price per ton.	Cost of application per acre.
		Per cent.	lbs.	Rs.	Rs. As. P.
1	Singhbhum Phosphate ...	35·2	227	75	7 9 0
2	Belgian Flour Phosphate	21·9	365	55	8 15 0
3	Indophos	26·0	308	65	8 15 0
4	Radiophos	23·5	340	72	10 14 0
5	Plutophos	35·5	225	120	12 1 0
6	Basic slag	17·9	447	75	14 15 0
7	Superphosphate ...	20·1	398	85	15 2 0
8	Bone Dust	21·2	377	100	16 13 0

Some of the mineral phosphates, it will be seen, can be applied very cheaply, and these experiments were undertaken mainly to determine their suitability for use with leguminous crops. The table below gives the results obtained. Soil variation was such that agreement between replicate experiments was not good, but the probable error calculated shows that the mean results quoted are significant, and give a fair estimate of the efficiencies of the various manures.

TABLE II.

Efficiencies of phosphatic manures compared to basic slag as 100.

Experiment.	1 Singhbhum phosphate.	2 Belgian Flour phosphate.	3 Indophos.	4 Radiophos.	5 Plutophos.	6 Superphosphate.	7 Bone meal.
No. 1 ...	1·4	73·2	0	5·7	19·0	88·3	88·3
No. 2 ...	16·6	48·9	0	0	39·1	74·4	111·6
No. 3 ...	0	61·1	22·7	9·8	31·8	92·7	92·7
No. 4 ...	10·7	58·8	5·2	39·3	24·8	153·8	76·9
No. 5 ...	0	85·1	4·1	5·3	25·0	57·7	53·3
No. 6 ...	3·4	40·0	31·7	20·6	44·4	93·0	106·9
Mean ...	**5·3%**	**61·2%**	**10·6%**	**13·5%**	**30·7%**	**93·3%**	**88·3%**
Probable error of mean ...	1·8	4·3	3·8	3·9	2·7	8·9	5·7

Manures numbered 1, 3 and 4, (Singhbhum phosphate, Indophos, and Radiophos) are all very similar, hard apatites of Indian origin. They are all very finely ground, but it will be seen from the above table that their efficiencies are so small as to be practically negligible.

No. 5, Plutophos, is not quite useless. It has a significant, though small, efficiency. Its cost (see Table I) however is relatively so high, that it could not be used in preference to basic slag.

No. 6, Belgian Phosphate, has a relatively high efficiency. If increasing the rate of application would give a propor-

tional increase in crop; then, if application at 80 lbs. per acre gives a 61 per cent. efficiency then application at $\frac{100}{61}$ times 80 lbs. per acre would give 100 per cent. efficiency. That is Belgian Phosphate to supply 131 lbs. phospheric acid per acre would give the same increase in crop as basic slag supplying 80 lbs. phosphoric acid per acre.

Relative costs would then be :—

	Phosphoric acid per acre.	Manure required per acre.	Cost per acre.
	lbs.	lbs.	Rs. As. p.
Belgian Phosphate ...	131	598	14 11 0
Basic slag ...	80	447	14 15 0

The application of these very different quantities of phosphoric acid would cost practically the same. If these applications would give equal increase of crop, Belgian Phosphate would be preferred on account of the much greater residual effect of the additional phosphoric acid supplied. An increased application of manure, however, generally gives less than a proportionate increase in crop. That is 131 lbs. phosphoric acid as Belgian Phosphate would be expected to give a somewhat smaller crop than would be obtained from 80 lbs. phosphoric acid as basic slag.

Whether basic slag or Belgian Phosphate would pay better in use, therefore, cannot be determined from the above figures.

Further information is desired on two points—

(1) The actual residual value of both manures.

(2) The immediate effect of increasing the rate of application of each manure.

The first point can only be determined after a number of years; for the present it may be assumed only that the 131 lbs. phosphoric acid as Belgian Phosphate would give a greater residual effect than 80 lbs. phosphoric acid as basic slag.

The second point however was examined by means of a further series of experiments using the two manures at differ-

ent rates. This experiment included trials with basic slag to supply 20, 40, 60, 80, 120 and 160 lbs. phosphoric acid per acre. Both Belgian Phosphate and also Radiophos (as an example of a very insoluble class of manure) were each tried at rates supplying 40, 80, 120, 160 and 240 lbs. phosphoric acid per acre.

Each manured line had unmanured lines immediately alongside for comparison.

Each experiment was repeated five times. The results below show the increase in crop obtained in ounces per plot of $\frac{1}{2000}$ acre. The increased crop is taken as the difference between the crop from a manured line and the mean of the unmanured lines on each side of it.

TABLE III.

Increased crop from Basic slag.

Rate of application lbs. phosphoric acid per acre.	20.	40.	60.	80.	120.	160.
Experiment 1 ...	7	17½	24	23½	26½	39
„ 2 ...	14	18½	33½	27	37½	37½
„ 3 ...	9½	13	28	41	46½	46
„ 4 ...	18½	14	22	31	37	44
„ 5 ...	9	20	16	16	28	20
Mean	**11·6**	**16·6**	**24·7**	**27·7**	**35·1**	**37·3**
Probable error of mean ...	1.7	0.9	2.0	2.8	2.4	3.1

Increased crop from Belgian Phosphate.

Rate of application lbs. phosphoric acid per acre.	40.	80.	120.	160.	240.
Experiment 1	9	14¼	19¾	12	18½
„ 2	6¼	17½	20¼	21¾	23¼
„ 3	12¼	33	20½	10¾	8½
„ 4	−½	17	14	11	18¼
„ 5	9½	7½	12½	8	11
Mean	**7·4**	**17·8**	**19·2**	**14·5**	**15·9**
Probable error of mean	1.4	2.7	.8	1.8	1.8

Increased crop from Radiophos.

Rate of application in lbs. phosphoric acid per acre.	40.	80.	120.	160.	240.
Experiment 1	-1	2½	4½	2	-1½
„ 2	-½	-1½	-3½	2½	5¾
„ 3	½	-3	-1½	¼	-8½
„ 4	-4½	...	-4	½	6
„ 5	3½	1¾	26½	6	1
Mean	-0·4	-0·02	+4·3	+1·4	+0·5

These results are clearly subject to a relatively large experimental error, but they still yield important results.

Of the 25 trials with Radiophos only one (the fifth experiment, at 120 lbs. per acre) yields any significant increase of crop. This happened to fall on an unusually fertile strip of soil. The other 24 experiments gave crops sometimes a little above and sometimes a little below that produced without any manure at all. It is perfectly clear that manures like Radiophos will give no significant increase within six weeks after application, at whatever rate the manure may be supplied. Such manures are therefore entirely unsuitable for use with green crops. The results from basic slag, on the other hand, show that even so small a dressing as 20 lbs. phosphoric acid per acre, in this form, gives a definite increase in crop, and that the gain increases as the rate of application of manure is increased.

The results from Belgian Phosphate, also, are subject to a high experimental error. It is clear, however, that all rates of application do give a definite increase in crop.

The results obtained with Belgian Phosphate would make it appear that maximum crop is obtained by the use of 120 lbs. phosphoric acid per acre, and that to increase the dose beyond this limit leads only to decreased crop. The more probable explanation, however, is that a maximum increase is obtained by the use of about 90 lbs. phosphoric acid per acre,

and that to increase the application beyond this limit merely gives no further increase. That is an increase of about 17 ozs. per plot (almost exactly 1 ton per acre) may be obtained by the use of about 5 mds. of Belgian Phosphate per acre, and any increase in the rate of application would give no additional crop within the period of six weeks.

The curves on the opposite page show these results more clearly.

It will be observed that the points obtained for Belgian Phosphate are such, that the curve for this manure can only be guessed at approximately. The results, however, clearly enough show that as far as immediate efficiency is concerned, there is a limit to the rate at which Belgian Phosphate should be used.

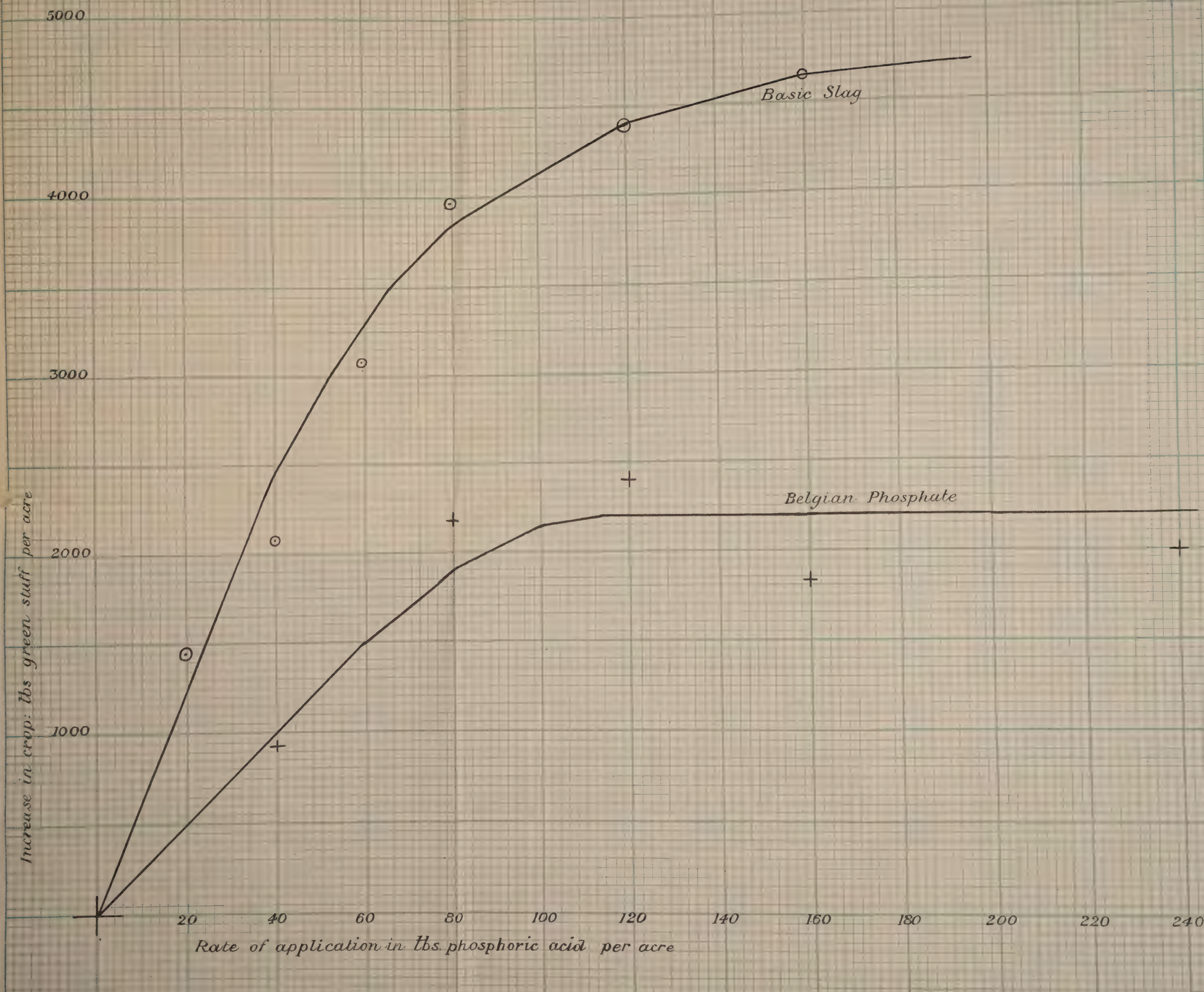
It is clear that, under the conditions of this experiment, no more effect can be obtained from Belgian Phosphate, at any rate of application, however high, than could be obtained from about 3 mds. of basic slag (43 lbs. phosphoric acid).

Where a dressing of 3 mds. basic slag per acre is a sufficient dressing, it can be replaced economically by 5 mds. of Belgian Phosphate.

The Belgian Phosphate will cost Rs. 9-13, as against Rs. 8 for the basic slag, but the difference represents a cheap rate for the higher residual value of double the quantity of Phosphoric acid. On those soils which require a greater immediate effect than can be obtained from these quantities, basic slag must be used.

It is only rarely that soils are so sensitive to Phosphoric acid as the Borbhetta soil used. On previous occasions we have found this soil improved enormously and immediately by large doses of Phosphate, whenever it is newly turned from grass. The same soil when cultivated and drained for a few years fails to show this extreme need for Phosphates.

Curves showing increase in Mati Kalai crop with varying quantities of phosphatic manures.



This land is very suitable for testing the relative efficiencies of different phosphatic manures, but not many soils would show increasing benefit from increasing doses of basic slag (as this soil does) up the very high limit of about 8 cwt. basic slag per acre.

During the time the crops were growing, also, rainfall was short. These experiments will, therefore, be repeated next spring on more normal soil to obtain a better idea of probable limits to useful rates of application.

For the present, however, whenever it is desired to help on a green crop on a soil known to grow legumes badly, a moderately large dressing of basic slag, rather than a very large dressing of any mineral phosphate is recommended.

This moderately large dressing need not be broadcast over the whole area (on many soils, indeed, too much phosphoric acid may produce a decrease in tea crop); but the moderate dose of 2 mds. basic slag per acre, if applied only along the lines where the green crop is to be sown will be concentrated on about one-third of the total area under tea and so give a local concentration about the roots of the green crop of 6 mds. per acre.

PROPOSED TOURING PROGRAMME OF OFFICERS

OF

THE SCIENTIFIC DEPARTMENT

Season 1927.

	P. H. Carpenter.	E. A. Andrews.	A. C. Tunstall.	H. R. Cooper.	C. R. Harler.	C. J. Harrison.
January	Dooars	Tocklai	Longai and Chargola	Tocklai	Dooars	Tocklai
February	North Lakimpur	Tocklai	Tocklai	Moran	North Cachar	Tocklai
March	Calcutta	Tocklai	Tocklai	Tocklai	Tocklai	Tocklai
April	Tocklai	Tocklai	Orang	Tocklai	Home leave	Chatla Bheel and Hailakandi.
May	Home leave	Dooars	Tocklai	Mangaldai		Tocklai
June		Cachar	Tocklai	Tocklai		Balisera and Luskerpore.
July		Dooars	Tezpur	Lakhipur		Tocklai
August		Terai	Tocklai	Tocklai		North Sylhet
September		Dooars	Hailakandi	Sonari		Tocklai
October		Doom Dooma	Tocklai	Tocklai	Tocklai	Dhansiri and Golaghat.
November	Tocklai	Tocklai	Tocklai	Tocklai	Nazira	Tocklai
December	Tocklai	Tocklai	Tocklai	Tocklai	Tocklai	Tocklai

The exact dates on which the above tours take place will be given later to the respective sub-district Chairmen. Managers desiring a visit from the Scientific Officer must inform the sub-district Chairman who will make out an itinerary for the touring officer.

CONTENTS

OF

THE QUARTERLY JOURNAL, 1926.

Unpruned Tea	1
Important Points in Tea Manufacture ...	13, 23
The Field Experiments at Tocklai	24
Meteorological Observation in Assam, 1925	31
A Few Notes on Blister Blight	42
The Treatment of Root Diseases	45
Cut-Back Tea	48
Meteorological Observation in the Dooars	61
Shade Trees	83
Pruning in Relation to Disease in the Surma Valley ...	103
Soil Survey--The Terai	108
The Packing and Storage of Tea Seed	126
Tea Termites in Ceylon	134
Spraying at Sylee	143
Observations on the Treatment of Fungus Diseases ...	151
Green Crops	170
Trials of Phosphatic Manures	176
Proposed Touring Programme for 1927	184
Index	185